Impacts of different initialisation techniques on the skill of global dynamical climate predictions

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Outline

The model

EC-Earth 2.3

- NEMO ocean model with ORCA1L42 configuration
- IFS atmospheric component (TL159 resolution)
- LIM2 sea-ice component directly embedded into NEMO
- The atmospheric and ocean components are coupled via OASIS3

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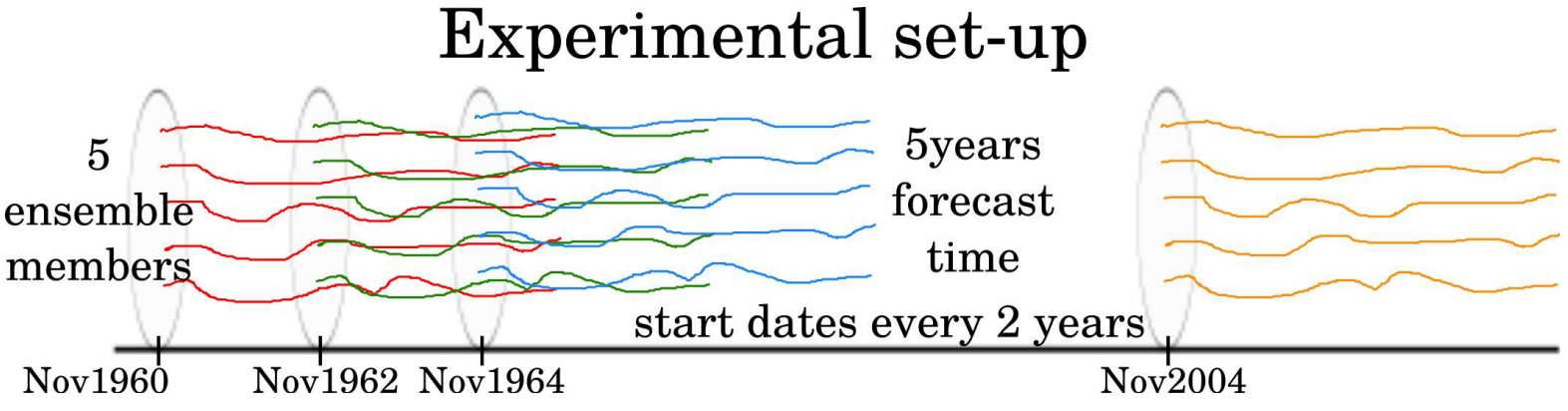
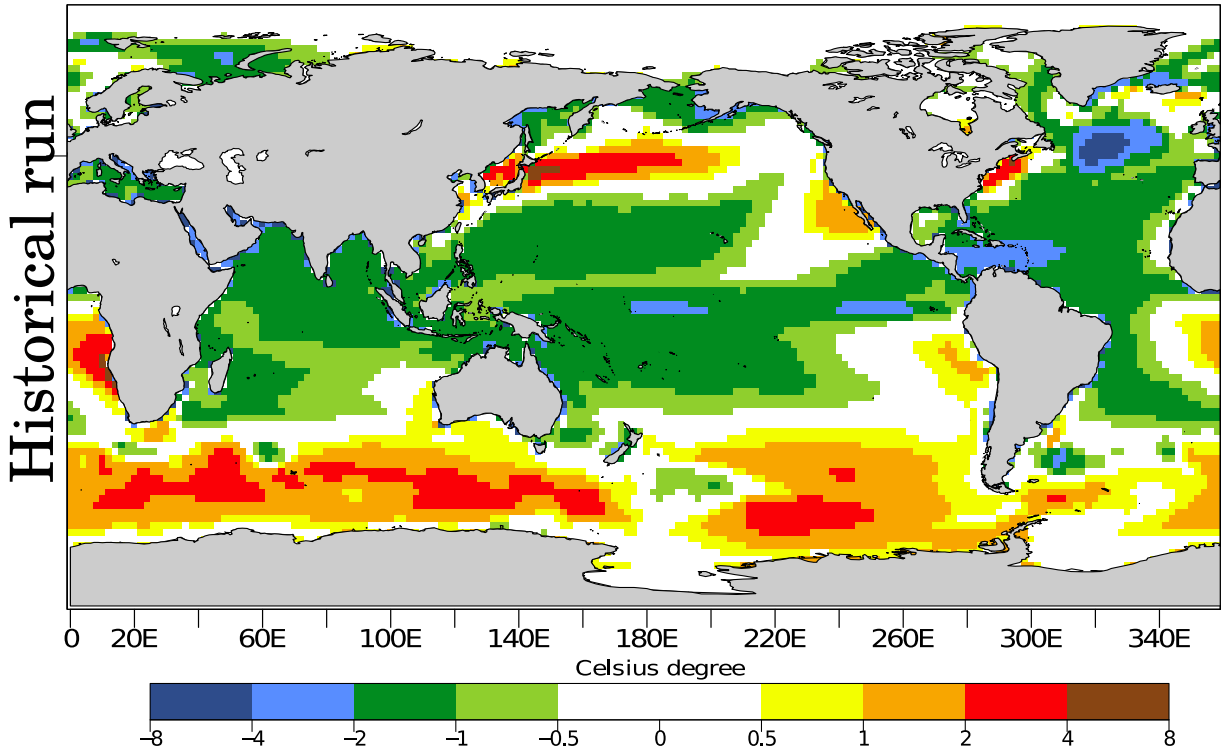


- 23 start dates
- 5 years forecast time
- 5 ensemble members

Sea surface temperature bias

Forecast year 1



- bias computed with ERSST reference data

Full field initialisation (FFI)

- The model is initialised with an estimate of the contemporaneous observed state:
  - ocean: NEMOVAR-ORA_S4
  - atmosphere: ERA40 and ERA-Interim
  - sea ice: reconstruction from MISU

Question

- How does the drift affect the skill of a prediction?

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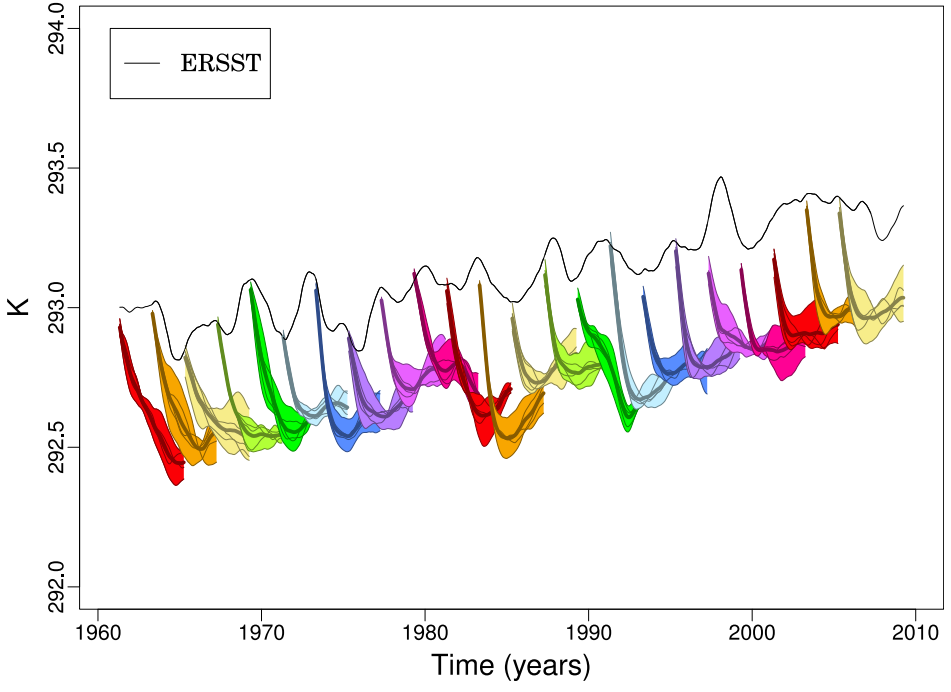
Sea surface temperature in a FFI experiment (start dates every 2 years)



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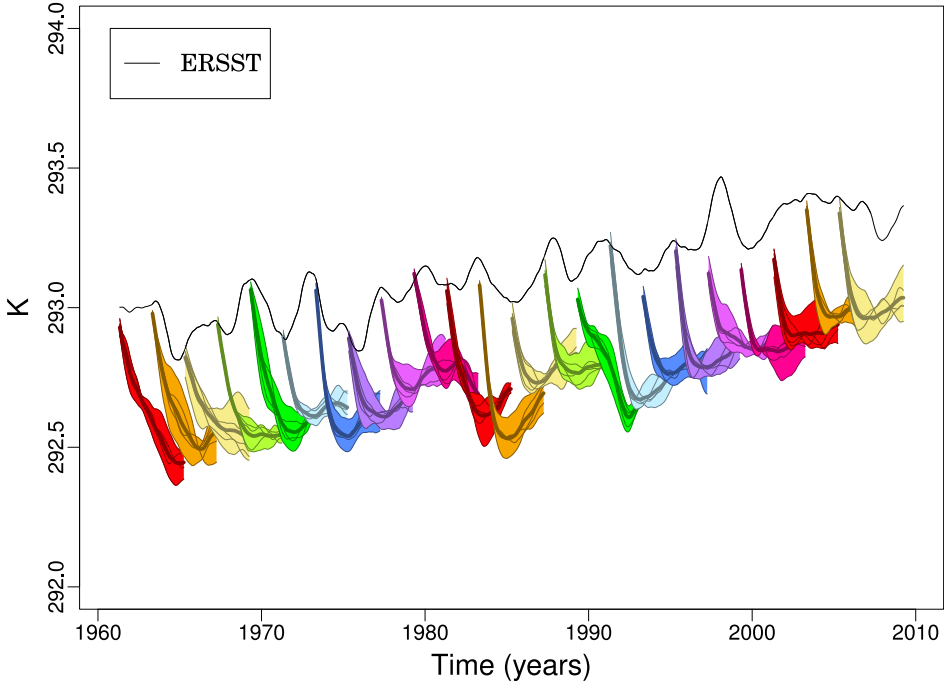

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Anomaly initialisation (AI)

Hypothesis

- If the simulated variability is independent of the model mean state, allowing the climate model biases (no drift) but constraining the phase of the simulated variability towards the contemporaneous observed one at the initialization time should result with an improved skill in the simulated variability

$$\underbrace{\mathbf{x}^a}_{\text{vector state of the assimilated variables}} = \underbrace{\mathbf{x}_i^o - <\mathbf{x}^o>}_{\text{observed anomalies}} + \underbrace{<\mathbf{x}^b>}_{\text{climatology of the model assimilated variables}}$$

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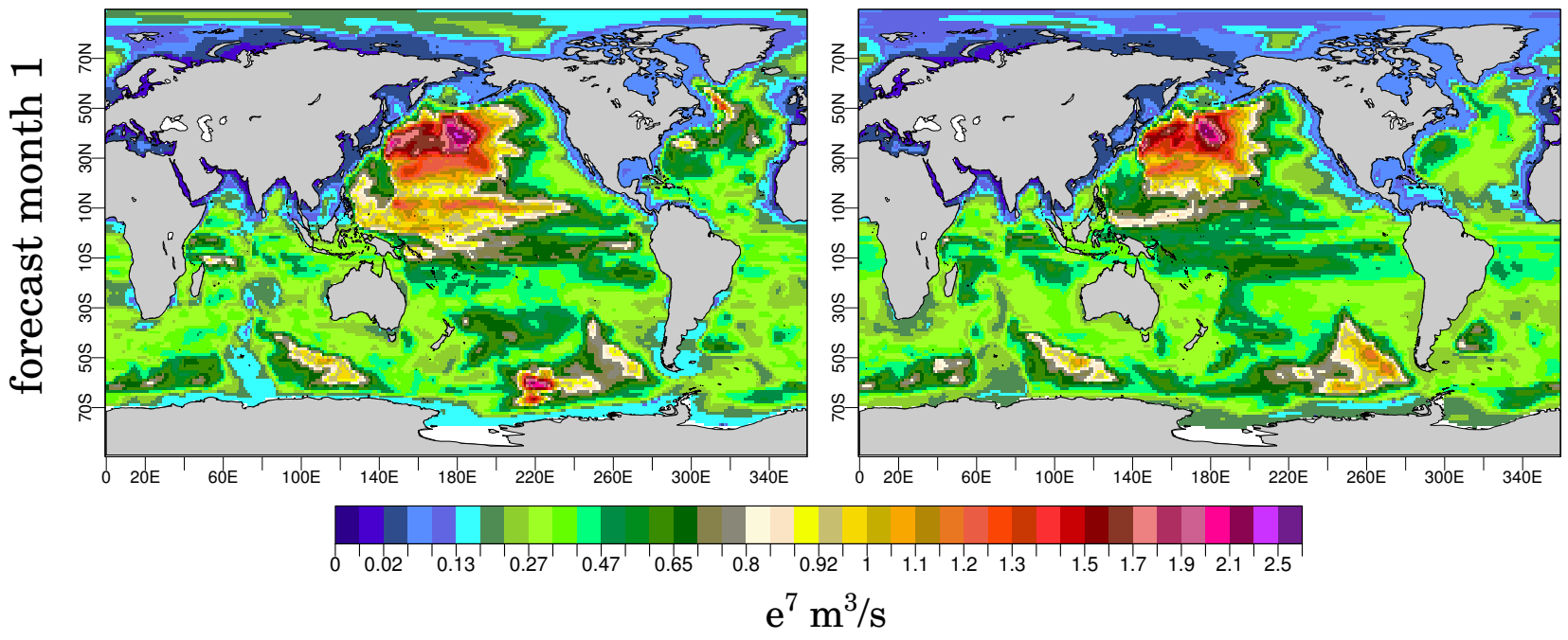
Standard deviation of the barotropic stream function

NEMOVAR-ORAS4
member 1

EC-Earth
member 1



- Calculated as the ocean horizontal transport integrated vertically

Improving AI technique

Weighted anomaly initialization

- To avoid the risk of introducing anomaly that are out of the model internal variability range, the observed anomalies used to initialize the model have been normalized
- The new initial state is given by:

$$\mathbf{x}^a = \frac{\sigma(\mathbf{x}^b)}{\sigma(\mathbf{x}^o)} \cdot (\mathbf{x}_i^o - < \mathbf{x}^o >) + < \mathbf{x}^b >$$

Initialization of the density

Improving AI technique

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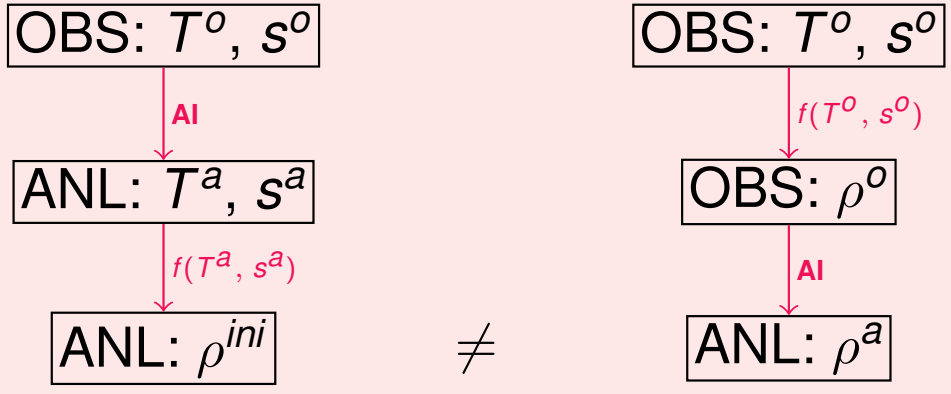
Initialization of the density



Implementation of the techniques

Historical run (NOINI) compared with:

Full Field Ini (FFI)

- atmosphere, sea-ice and ocean initialized from full field observed state

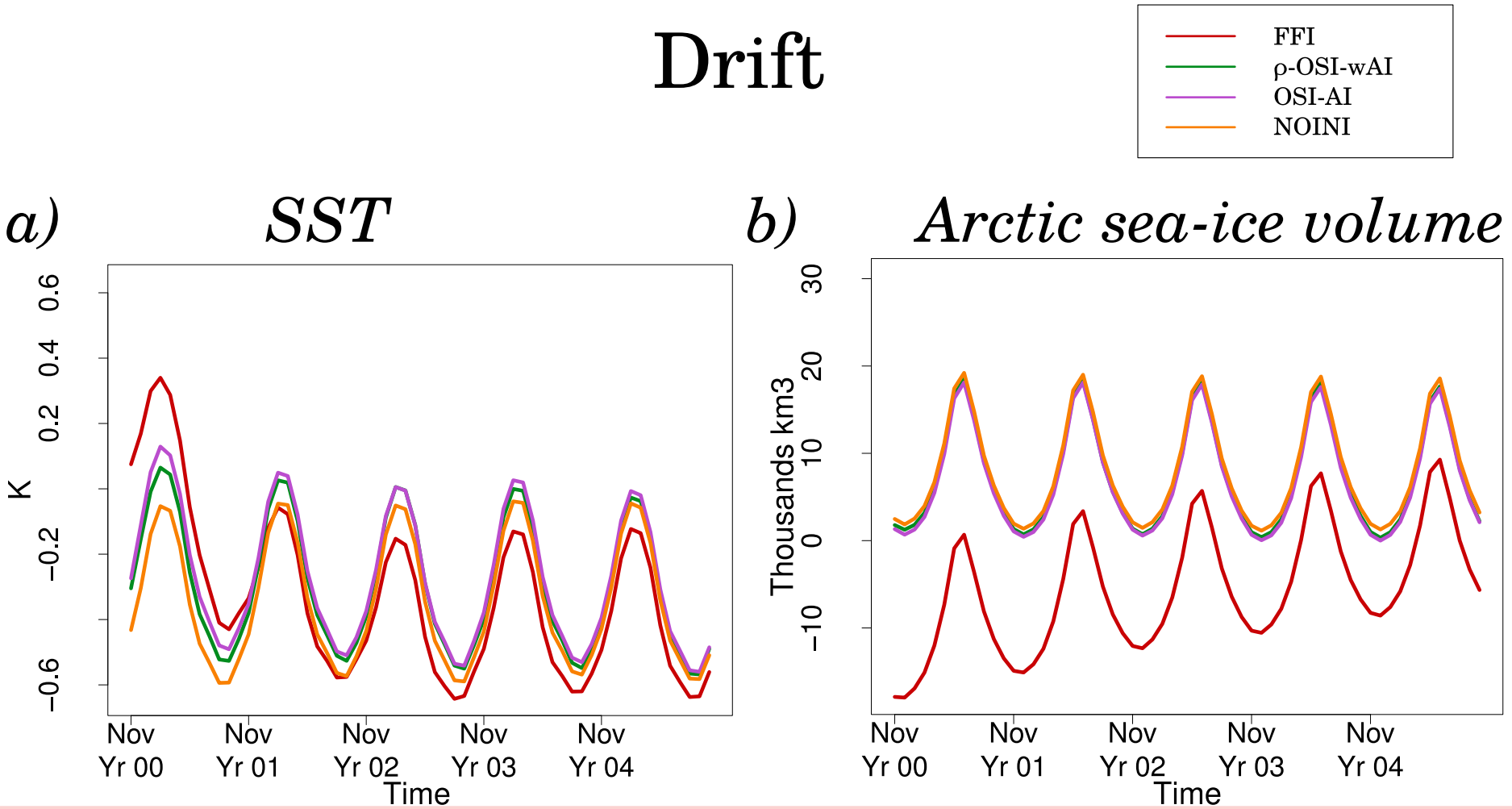
Ocean and Sea Ice Anom Ini (OSI-AI)

- ocean and sea-ice anomaly initialization
- atmosphere full-field initialization

Ocean and Sea Ice weighted Anom, with density Ini (ρOSI-wAI)

- ocean and sea-ice weighted anomaly initialization with initialization of T and ρ (instead of T and s)
- atmosphere full-field initialization

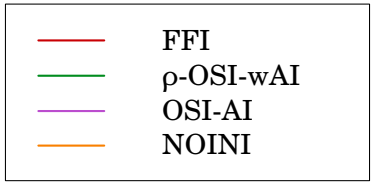
Drift



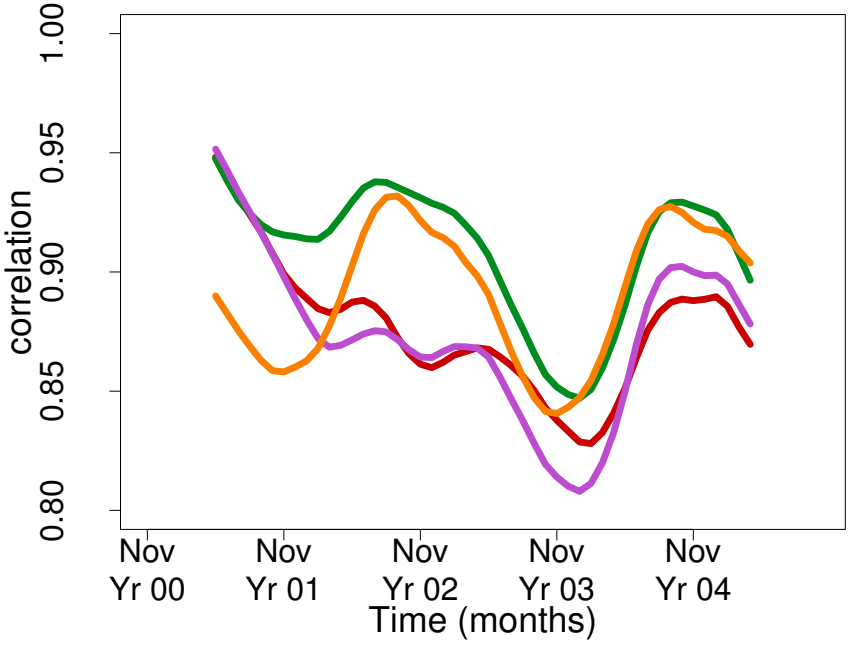
Reference data

- SST: ERSST
- sea-ice volume: sea-ice reconstruction proposed by Guemas et al.(2013) used also for AI implementation

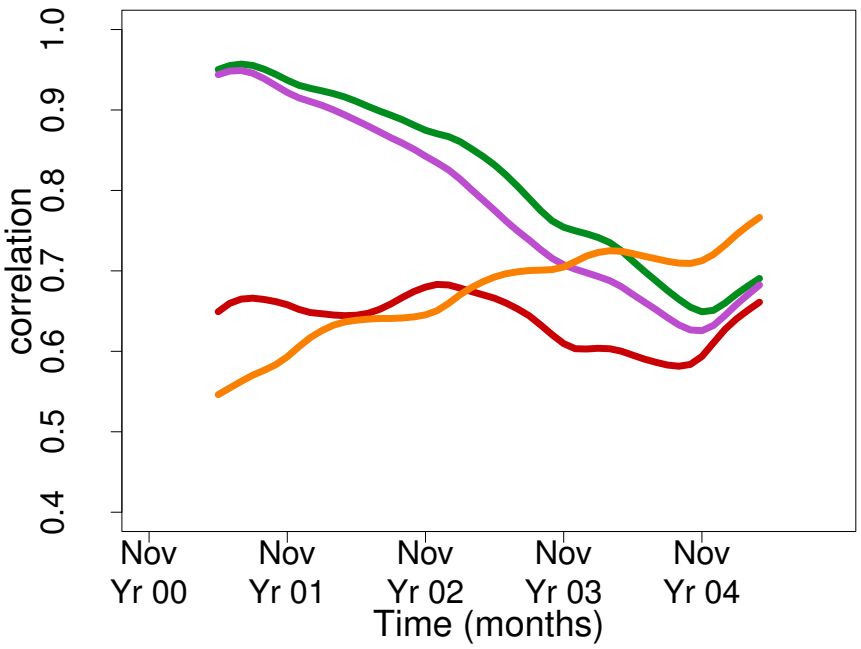
Correlation



SST



Arctic sea-ice volume



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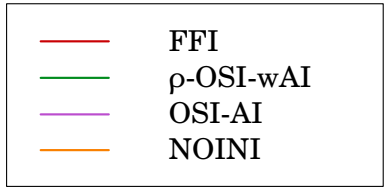
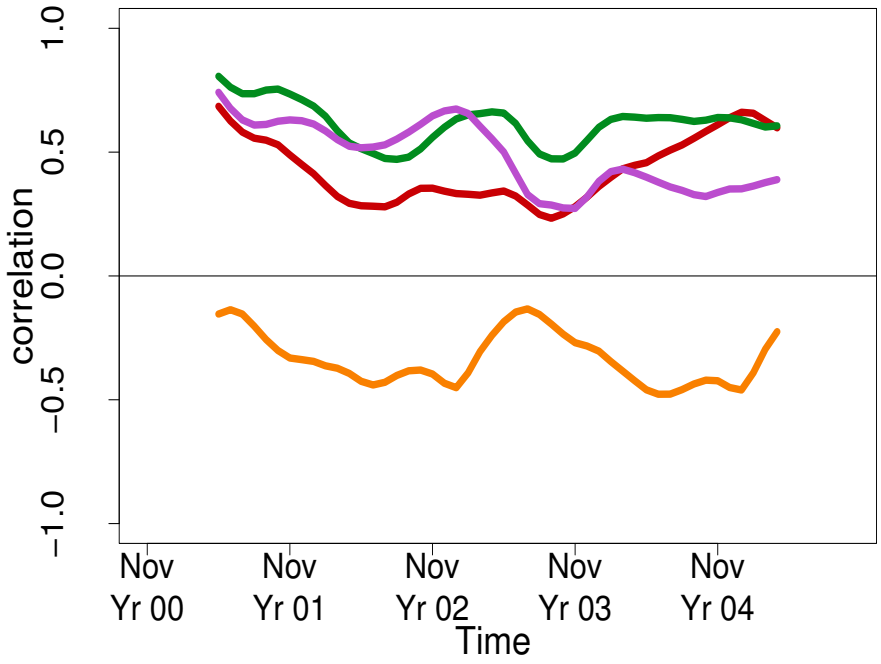
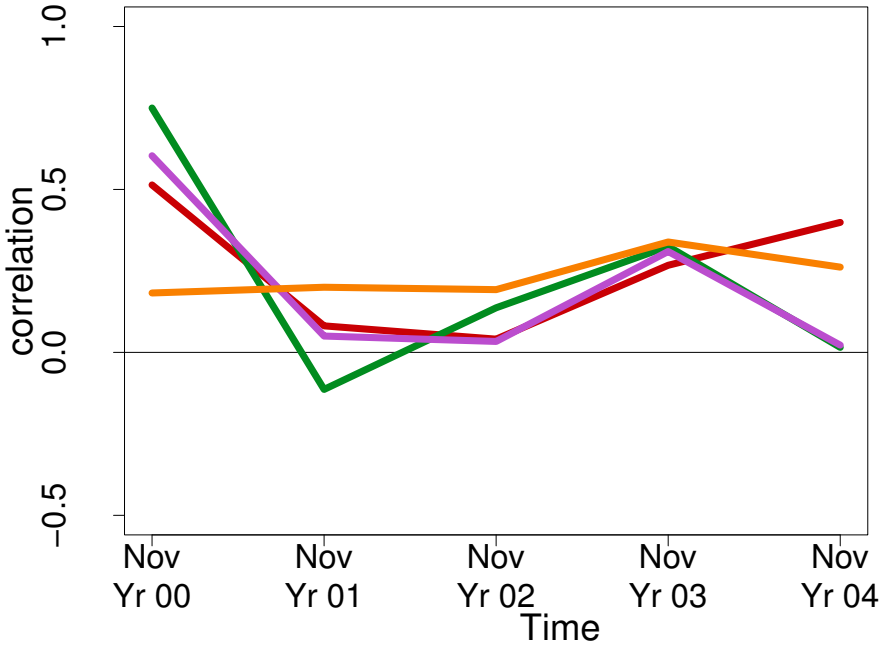


Atlantic Multidecadal Oscillation

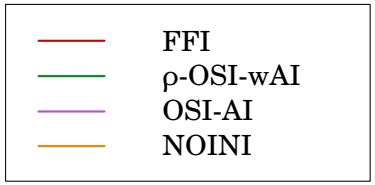


Pacific Decadal Oscillation



- The AMO is calculated as the difference between the SST anomalies in the North Atlantic (0-60N) and the global SST anomalies
- The PDO index is defined as the leading principal component of the North Pacific (20N-65N) annual sea surface temperature variability

Significant improvements over NOINI



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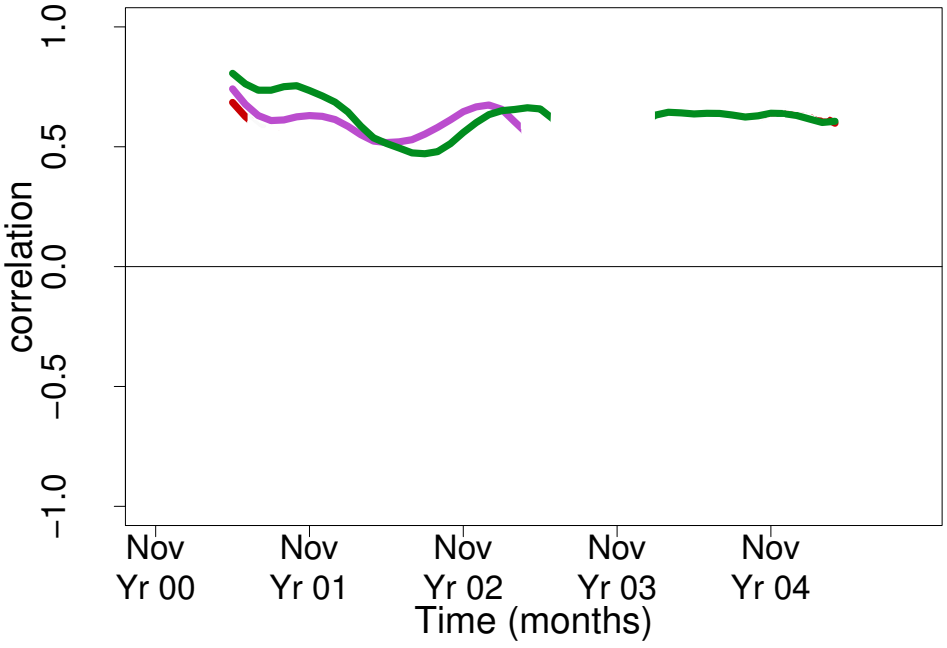

Pacific Decadal Oscillation

No significant improvements

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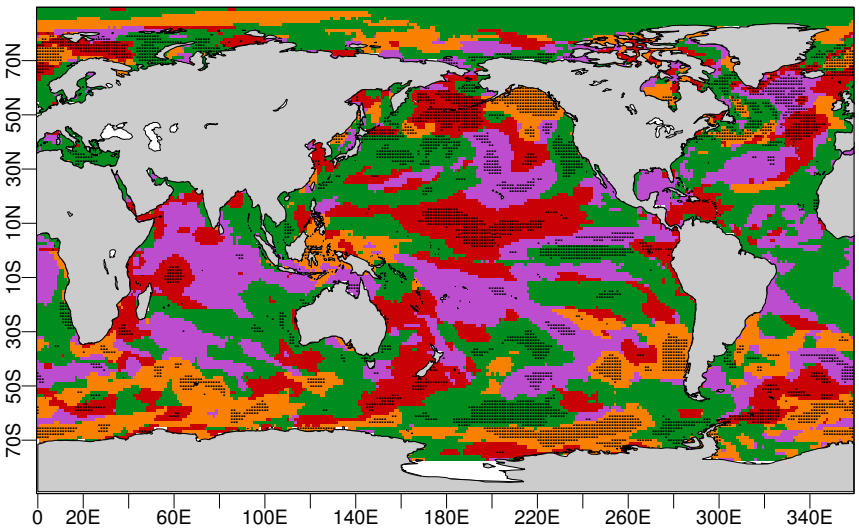
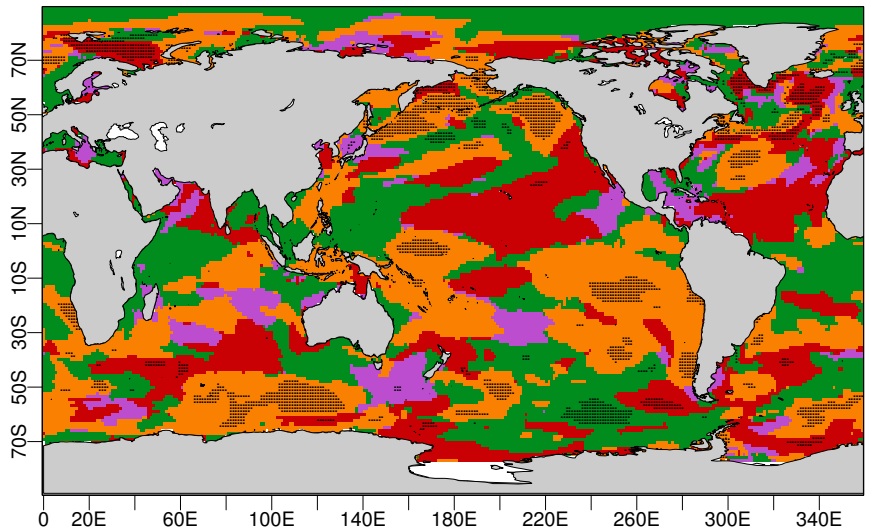
SST mimimum RMSE

Forecast year 1



Forecast years 2-5



FFI | ρ-OSI-wAI | OSI-AI | NOINI

Summary

The improved anomaly initialised experiment (ρOSI-wAI):

- further reduces the drift of SST
- performs the best for AMO along the whole forecast period and its skill is significantly larger than NOINI
- improves the PDO skill for the first forecast year
- improves the Arctic sea-ice volume for the first 3 forecast years

Thank you!